



## **Transition via R&D: emerging forms and strategies of corporate R&D in the catch up countries (Lithuanian case)**

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### **Introduction**

It is widely and commonly agreed that science and technology progress is among the key drivers in the catching –up process (Verspagen 1999, Dyker, Radosevic, 2001). The catching up, being defined as diffusion of technology from advanced countries to the catch up countries (Verspagen, 1999), is approached in the new EU member states for more than a decade. These processes has taken different paths, following diversified catching up strategies chosen by countries. Some of them were highly FDI driven processes (Hungary, Estonia), and some were more relying on their own resources and capacities, with relatively low FDI rates (like Lithuania). However, in the contrary to the common theory, the FDI supported technology transfer and high – tech exports growth didn't led to high value added creation within the transition economies, but rather an opposite – diminution of the most sophisticated value chain components in the national economies, giving the syndrome of „Latino Americanization“ of the new EU countries (see Reinert and Kattel, 2004). Moreover, it didn't led to the sustainable integration into the international trade, as the case of Estonia shows (Simasius, 2008). Neither the hope that strong national innovation inputs (using European Innovation Scoreboard terminology) will automatically build the long term technology based growth path was realistic. The processes of catch up did not happen naturally neither are going to be so in the future. Moreover, the catching – up countries, especially small ones, are setting the ambitions high – to find its own positions in global technology chains via diversification and specialization in high tech, R&D intensive niche production, and to “leap – frog” via the brake trough in certain R&D intensive technology and business areas, following the technology waves supported opportunity (Perez, 2002,2004). However, this is not to be achieved without considerable institutional transformation, which would result in a new ways of value creation and collaboration forms between R&D and business sectors, and the development of domestic technological capabilities. Namely, those two sectors continuously failed in CEE countries in cooperation for innovative growth and upgrade of industries, and the technology base was and and still is advanced mainly by the technology transfer from the more advanced countries. The fact is explained by the inherited disciplinary structure of the science of post-communist countries (Kozlowski, Radosevic, Ircha, 1999), separated science and industrial sectors, following linear model of innovation (Lithuania, aiming for knowledge economy. WB, 2002), and general profile of R&D systems, which is characterized by research

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or science than technology and innovation orientation when compared to high-income EU (Mickiewicz, Radošević, 2001). The situation has not changed much during the past decade, and the recent data (EIS, 2006) show the same institutional gaps between Science and business systems, resulting in extremely low corporate R&D rates with all consequences for industrial and employment structure within an economy, which especially in Lithuanian case is characterized by high S&T graduate levels, but relatively low employment rates in high or mid high - tech industry sectors, relatively low share of high value added in exports, etc. The R&D specialization report for Lithuania (Erawatch, 2007) identifies the mismatches between science, technological and economical orientations of the country, which also means that main growth sources of the economy remain in exploiting other than technological capabilities.

Still, it is commonly agreed that future growth will highly depend on business R&D capabilities to develop original knowledge that would support future growth of the economy. However, it is very little understood what are the key factors, driving the development of technological knowledge within certain NIS, and how policy could support corporate R&D development because of the lack of knowledge and understanding of businesses R&D profiles in post – communist countries. It is evident that they are not following Western European models, neither science sector does so (Radošević, Kriaucionienė, 2007), which is partially replacing business R&D functions within those economies. Statistically, business R&D is at the very low level in Lithuania (Erawatch Country Baseload Report, 2007-2008), very much like in the neighboring Baltic Republics, that shared the common past. The implementation of western innovation support models, such as technology business incubators, science and technology parks actually is not showing expected results, as institutional mismatches and differences in the interests of actors are too high.

However, highly R&D intensive companies are emerging in various sectors of the economy, including traditional (medium-high tech) sectors. If we only could capture those processes and use them as an evidence base for the corporate R&D support and technological advancement policies, we could expect to induce the development of technological capabilities within those countries. Based on this problem formulation, the objective of our study is, from the empirical stand point, explore the existence and essence of these new corporate R&D forms in different types of innovative companies from the same sector. On purpose, we do not choose highly escalated but moderately performing in national economy terms so called priority sectors (biotechnology, lasers, or nanotechnologies), which in Lithuanian case are basically represented by R&D institutes spin-offs, but aim to look at the maintained important industrial sector with a long term tradition and relatively strong capacities in terms of experience, knowledge and concentration of competencies within the country – electronics. Specifically, we will look at the transformation and upgrade in the value chain towards high tech – high –end of the electronic sector through R&D, and firm strategies and various organizational forms to achieve this, both successful and not.

The research methodology adopted is the case study, best suited to the objectives of our study: constructing theoretical approaches and revealing still relatively unknown aspects of the relationships being studied (Eisenhardt, 1995, Lee, 1999). We have selected four different companies, of different size, from the electronics sector, which all took different paths of transformation via R&D.

In the first section, we look at the general profile of Lithuanian electronic sector, in terms of GDP contribution, exports, employment, productivity, and R&D intensity. Here we also analyse the general framework conditions, based on statistical

indicators, such as human resources for S&T, R&D funding, science, technological and industrial specialization of the country, and also public policies, reinforcing the approached trends.

In a second part of the paper, we look on how different companies were exploring their own ways in R&D based development within the same given conditions, but resulting in different positions in terms of growth, internationalization, value added, and general competitiveness, applying the case study method. Here we also look at the key forces and situations that impacted the specific approaches to change and development of technological capabilities in a certain way. We find that both – research and development oriented innovative activity models apply within Lithuanian electronic sector companies, which is mainly related to the evolution of the firm and its position within the market, sector and the value chain.

We result in discussing successful and unsuccessful business R&D strategies, reinforced by the innovation and R&D policies, and conclude with the policy recommendations and further research questions.

### **General profile of Lithuanian electronics sector (NACE 31 – 33)**

Lithuanian industrial production since 1991 decreased dramatically, and still has not reached the initial production rates. Among the industries, heavily resifted during the deindustrialization period electronics (NACE 31 – 33) falls as well. The whole machinery and equipment industry was one of the most affected by the process of deindustrialization – production volumes in 1997 dropped by 85% compared to 1990. Although since then the production of electronic was increasing, it has not reached the level of 1990 yet.

Still, electronics remained one of the most important industries in Lithuania, contributing 1.2 % to GDP in 2006, while total industrial production did 19,75%. Electronics created up to 7% of total industrial production and 7.2% of total Lithuanian exports in 2006. There are 500 enterprises in Lithuania, which can be assigned to the sector of electronics and electronic equipment with close to 20 000 employees. The industry is comprised of highly specialized enterprises in large scale production, as well as in niche markets. Scientific knowledge for electronic industry is basically provided by public R&D institutes in Physics, located in Vilnius, and Kaunas University of Technology, which is focusing on applied research and development.

Private R&D expenditures of the sector (NACE 31 – 33) amounted 1.767 mio EUR in 2003. The share of R&D expenditures of electronics industry in total BERD exceeded 7.61%, and made 12,9 % of the private R&D expenditures in manufacturing in the same year. R&D expenditures in electronics grew dramatically in manufacture of electrical equipment and apparatus (NACE 31, more than 10 times), and manufacture of medical, precision and optical instruments (NACE 33, more than 4 times) in the period 2001 - 2003. The statistical R&D figure in manufacture of radio, television and communication equipment and apparatus in the same period was declining, as a result of cutting investments by two large size enterprises, which bankrupted in 2006 and will be discussed in the next section.

The number of researchers in electronic sector is the highest compared to any other Lithuanian business sector. Total number of employees, engaged in NACE 31-33

R&D was 566 in 2005, and comprised 36% of the total R&D employment in business sector. 279 of them - researchers and engineers, or 30% of all researchers employed in manufacturing. S&T graduates in the field of electronics reach 200 yearly, but many of them later are not directly engaged in R&D, thus not reported in statistics.

Key performance indicators for Lithuanian electronic sector (DL, NACE 31-33) are summarized in the Table 1.

**Table 1. Key performance indicators of Lithuanian electronic sector (DL, NACE 31-33)**

	<i>dl31 Manufacture of electrical machinery and apparatus n.e.c.</i>	<i>dl32 Manufacture of radio. television and communication equipment and apparatus</i>	<i>dl33 Manufacture of medical. precision and optical instruments. watches and clocks</i>
<i>R&amp;D investments, mio EUR</i>			
2001	:	16,492	0.184
2002	0.52	0.983	0.578
2003	0.579	0.406	0.782
<i>R&amp;D as Percentage of total BERD</i>	2.49%	1.75%	3.37%
<i>R&amp;D as a percentage of R&amp;D in total Manufacturing</i>	4.22%	2.96%	5.70%
<i>Total R&amp;D personnel</i>	101	276	189
<i>Researchers and engineers</i>	63	136	37
<i>Production volumes, mio EUR, 2006</i>	259.7	243.1	95.6
<i>Production share in total manufacturing, 2006</i>	2.2%	2.1%	0.81%
<i>Sold in the Lithuanian market,</i>	26,9 %	19,4 %	36,8%
<i>Sold in the non-Lithuanian market, %</i>	73,1%	80,6%	63,2%

### **Specific framework conditions for Lithuanian electronic industry**

Electronic industry, assigned to high tech industries, similarly to other industries of such type is highly shaped by global competitive landscape. Global technology chains, large scale industrial production, division of production and labour among countries, widely spread competencies are few of the important features of the electronic industry today.

Lithuanian electronic industry was and still composed by variety of branches – electrical and electronic equipment, both – for industry and household, broadcasting equipment, TVset and vacuum tube as well as related component production, but also medical and metering devices. Year 2006 featured with the bankruptcy of two largest factories from the electronic industry – “Panevezio Ekranas” (vacuum tube producer) and its supplier – large producer of TV tube deflectors “Vilniaus Vingis”, although both of the LSE’s were at the first glance successfully operating enterprises. At the same time, we approached emergence and prosperity of new or heavily reconstructed via downsizing old companies, which had found their way through changes, and as we can see today – it was successful. We have applied case study method and selected 4 different companies in order to understand their strategic decisions concerning growth and even more – R&D based growth as a key success factor. The questions we raised were concerning growth rates, markets, human resources, but also we had an aim to

capture specific strategic thinking beyond the results that we see today. Not surprisingly, we arrived to many of the statements supported by evolutionary theory and development of technology paths. Even more, we saw, how companies can explore their evolutionary paths via innovative behavior, which was always related to R&D.

Thus, the first common feature that we found among all companies was deep understanding of the electronic industry specific features in Lithuania, which were mainly defined by the Soviet R&D and production system. What were those features? First of all, it was one of the top industries in Lithuania, highly supported by Soviet government, and needless to say – soviet military funds for R&D. Many of the R&D and industrial developments were Soviet defense system oriented. The industry consisted of the whole chain of knowledge creation and exploitation - institutes of fundamental research in physics, higher education schools with high concentration on applied research and technology development, and finally – industrial R&D institutes (or so called constructor bureaus) as internal structures of large electronic factories. From the Soviet system point of view, Lithuania, together with other Baltic countries, was a top leading countries in R&D, industrialization and economic development. Lithuania was targeted by specific Soviet R&D policy, which resulted in development of Lithuanian R&D institutes for the wide knowledge needs of the all Soviet system in the field of electronics. This allowed developing a broad knowledge base and ability to create R&D based new technologies. Lithuania, after regaining independency in 1991 has left circa 6000 patents within Soviet legacy system. In addition, R&D and competence development cost were close to 0, enabling institutions and researchers to establish broad absorptive capacities.

Complementary, higher education sector has been producing extremely large numbers of engineers in the field of electronics. Entire tendency is still maintained today (S&T graduates make 17% of total, EIS 2006), and gives to Lithuania one of the few leading positions in European innovation scoreboard.

More specifically, the successful companies we studied were able to explore specific conditions for electronic sector that existed and still are maintained in Lithuania today. These conditions are basically characterized by following points:

- ?? Inherited strong R&D potential in physics and radioelectronical engineering, which was retained to the significant extent from the Soviet period
- ?? Close to zero costs of changing research interests and/or area for both – the researcher, and the institution in Soviet R&D system, which allowed to develop broad competence base, and even more – ability to change and adapt to new research contexts, which was also supported with the broadened absorptive capacity.
- ?? Broadly developed higher education base for engineers, and the concept of electronic engineering as a systemic discipline, which produced a large number of highly qualified labor with applied systemic thinking.
- ?? Global production of components for electronic industry, which allows to develop original final products to market without establishing the whole production chain in a certain location.

These key characteristics of Lithuanian electronic sector combined with the *hug wave of changes* starting with independence of 1991, and basically characterized, first of all by disconnection from Soviet R&D and industrial system, destruction of planned

markets for both – R&D and industrial production, and, however, non existing national R&D system. These were starting points for the restructuring of the whole Lithuanian industry.

The easiest and cheapest way for undergoing changes probably would have been cutting the most advanced areas of production and manufacturing via becoming production agents for multinationals in mid and high tech industries, as it has become in some other new EU member countries. However, many factors, including conservative restructuring policy of Lithuanian government has led to different decisions. The switching from planned to market economy related changes are not presentable within this paper, but are broadly analysed by wide range of researchers. 3 of 4 of our case study companies were able to recognize and explore those changes for R&D based innovation and competitiveness.

### **Exploring change via creative destruction and R&D – the cases of Lithuanian electronic companies**

The emergence of our first case study company – currently “**Axis Industries**”, is related to one of the fundamental needs of economy – effectiveness in exploitation of resources, first of all electricity, gas and oil, and consequently, policy impact for the whole industry of measurement devices. In mid 1990 Lithuanian Parliament has approved the basics for energy saving – diversified tariffication system for electricity use, which immediately created demand for new metering devices for commercial heat, water, natural gas and electricity supplies. The global companies, such as Danfos and Siemens, were ready to offer the finalized solutions for to be implemented in Lithuanian industry. However, the group of Lithuanian researchers and engineers, having realized that *all competencies and solutions to develop metering devices are in place, and all the desired components are available on the global market place*, has established company “Katra” which started to produce industrial automatisation applications, control and measurement devices, and today forms the base of a company group “Axis Industries”. Naturally, at the time there was a large discussion on why to design and produce original products, if there was an easier opportunity - to import from elsewhere. However, the need to survive has led to alternative decisions. Company used few of the classical competitive advantages - *much lower costs combined with competencies and institutionally impacted demand for new products* – energy metering devices. In addition, the period of 1995 has given the chance to operate in the local Lithuanian market, while Eastern markets were closing, and Western markets were too complicated for entry with the final product because of quality regulations and product certification procedures, but also because of the lack of market knowledge. This gave the resources and time for company to develop original and today internationally delivered solutions. In the later stages of development, it was merged with other complementary companies, engaged in manufacturing of biofuell and heating equipment, and many other industrial applications. As a result systemic competencies were gained.

Our next case company, “**Vittamed technologies**” has emerged as a case of academic entrepreneurship. The key factor for its establishment was not a technology procurement (as in the previous case), but a vital need to change in order to survive. The critical point for change was closing Russian market for R&D, as well as R&D funding, which was not replaced by national, Lithuanian, R&D funding. The key resources the research group had was *systemic competencies in physics, metrics, radio*

*technique, which were applied in developments for Soviet aero cosmic programmes; and ability to reconstruct existing competencies for new applications.* As a result, it has created an emerging product to be presented in the global market in 2007, after years of international clinical testing and improvements, – a noninvasive intracranial pressure measurement device, having no analogue worldwide and based on more than 10 patents. The core competencies of the firm was deep understanding of physics (semiconductor physics, surface atom physics, liquid physics and radio electronics) and industrial metrics, which were transformed from industrial to physiological landscape. But for this transfer specific clinical and physiological knowledge was needed, and it was acquired from the Kaunas medical university at the first stage. The emergence of device was a pure case of innovation via *merging two different knowledge fields* – the one of physics and industrial measurements, and the other of medicine and physiological measurements – blood pressure, which has not changed much since 1904, when J.Erlanger invented arterial blood pressure device and got his Nobel Prize in 1944. However, noninvasive intracranial pressure measurement devices after more than 100 years still not existed in the global market until Vittamed has patented its innovative device in the USA and EU. Arterial blood pressure (ABP) and intracranial pressure (ICP) are physiological parameters of the same importance because the blood flow through the human brain depends on the difference between ABP and ICP. *International patenting of innovative solutions has opened the access to internationally available resources for R&D. The competencies that were desired by Russian military in the past, were also appreciated by USA Department of Defense* with the grant of 0,5 million USD for clinical research. Later the resources were acquired from EU Framework programmes, and Structural Funds, reaching 2 million of Euro. Lacking specific knowledge was acquired first of all via open academic networks (local ones primarily), and later via open innovation network established with international partners – Spencer technologies and BrainIT group ([www.brainit.org](http://www.brainit.org)) . Entire cooperation has led to 5 more patentable solutions in the field.

Similar impact to change experienced the third selected company “**Television Technique**” – today a supplier of TV broadcasting system design, integration and installation domain. The company emerged as a result of bankruptcy of former Television Technique Research Institute, which, differently from the previous case was of an industrial type, and specialized in the development of broadcasting systems. Only few examples: it served Moscow Olympic games in 1980, as well as the large Soviet market, with more than 150 coach building of OB Van together with Finland company Ajokki, including those for operation in a countries with extremely harsh weather conditions with high humidity, hot and dust climate - Cuba, Turkmenistan, Uzbekistan, Tadjikistan, Kirgistan, Azerbaijan. The institute was not retained in the industry restructurisation course and collapse of the whole R&D and industrial system, but *the competencies to develop system solutions and produce broadcasting applications for different clime environments* (from very hot and dusty in Close East to very cold in Sibiria), *as well as act in multicultural markets were retained.* The company explored all the opportunities the change offered – it has cut production of components and started to explore global supply sources, in the same time downsized from 200 employees to 28, top level engineers only, equipped with systemic competencies and market knowledge, and concentrated on systems design and implementation at the first stage in Russian and SNG markets (the former Institute markets), and later on markets, less sensitive for reputation links, but in need for

quality such as Uzbekistan, Azerbaijan, Jordan, Kuwait. Earlier competencies were explored with much higher flexibility and dynamism, and strengthened with a continues customer and supplier driven innovation, developed via internal in house R&D processes, and supported by local university, first of all via cooperation in education of new engineers for company needs.

The forth case of our study – “**Vilniaus Vingis**”, large Size producer of TV tube deflectors for Vacuum tubes, with close to 2000 employees, successfully operating in local market until joint bankruptcy with the large size Lithuanian vacuum tubes producer “Panevezio Ekranas”. The company was successful until its main customer – vacuum tubes producer was operational, achieving annual turnover of 30 million EUR per year. However, both of them were operating on the declining end of outdated technology wave, and explored the market of vacuum tubes when everybody else was leaving it with innovative solutions. Still, at the fist glance the company was innovative. It invested in local R&D, very similarly to the others, and obtained even R&D department. However, in house R&D was mainly incremental improvements oriented, and the R&D institutes the company has chosen for cooperation, were of fundamental type – thus with no engineering knowledge, neither ability to transform scientific inventions to industrial applications for a scale producers. R&D efforts, although supported by company and Phare 2002 funds, were too weak, and actually too late in time. The company has followed the path of all previously bankrupted LSEs of Lithuanian electronic sector. It seems that the company, despite R&D efforts, was not able to explore change and set a new strategic course during the period of 15 years, which was in fact the historically given period for transition.

## Analysis and discussion

After a short presentation of cases, we will summarize a key strategy points across following dimensions: basic characteristics of the company, such as evolutionary profile, size, number of employees, and proportion of highly qualified, annual turnover and growth rates, and market related data, such as domestic and export orientation. Later on, from the stand point of strategy design we have a look at the sources of competitiveness, and growth sources, as a precondition for a firm strategy. Than we look at the intensity and profile of firms R&D activities, and even more specifically – at its outputs in a form of intellectual property and/or unique products to market. Specifically, we also wanted to look at how R&D activities and by R&D orientation pre defined profile allow companies to create competitive advantages in markets. The key findings on each category are summarized in the tables below.

**Table 2. R&D based company profile – specific features**

Profile of the company				
Dimension	Axis industries	Vittamed technologies	Television technique	Vilniaus Vingis
Core product	Ultrasonic and electromagnetic heat and flow meters, energy calculation devices, water meters, industrial metering, data collection and remote control systems.	Non invasive intracranial blood pressure measurement device	TV broadcasting system design and implementation	TV linking system
Year of	2006, as a merge of	2002	1996	1959



establishment	3 enterprises			
Size of Company	Large enterprise	Micro enterprise	Small enterprise	Large enterprise
Rationale for establishment	State technology procurement	Invention	Bankrupt of the industrial R&D institute	Privatization of state enterprise
Evolutionary profile	State R&D establishment	State R&D establishment	Industrial R&D institute	Large scale industrial producer
Number of employees, 2005	650	18	28	1631
% of employees with 2 <sup>nd</sup> and 3 <sup>rd</sup> level higher education	20%	100%	90%	15%
Annual turnover, 2005, mio EUR	30	1.7	1.8	30
Growth rates in 5 years period	300%	300%	300%	n/a
Sales, internal market	60%	0%	5%	90%
Sales, abroad	40%	100%	95%	10%
Market orientation, in the moment of establishment	Local	Western, global	Eastern, international	Local
Market orientation, 2006	Local and international, neighboring	Western, global	Eastern and Close East, international	Local

**Table 2. Sources of competitiveness and growth**

Dimension	Axis industries	Vittamed technologies	Television technique	Vilniaus Vingis
<b>Sources of competitiveness</b>				
Access to final customer with original product	YES	YES	YES	NO
Position in technology life cycle	Independent, as system designer and integrator	Emerging	Independent, as system designer and integrator	Declining
Competencies of geographical location	Applied R&D and engineering, dominating	Applied R&D and engineering, dominating	Industrial R&D and engineering, dominating	Fundamental R&D, dominating
<b>Growth sources</b>				
Change drivers	Market opportunity	Disconnection from Soviet R&D resources and markets	Disconnection from Soviet markets	None
Drivers of growth	R&D and merge of companies with complementary competencies	R&D and international patenting	Restructurisation and continues improvement	Dependent on growth of local purchaser
Human resources development	In close cooperation with technological university	In close cooperation with technological university	In close cooperation with technological university	In close cooperation with fundamental Science institutes and university

**Table 4. R&D profile and strategy**

<b>R&amp;D profile and strategy</b>				
Dimension	Axis industries	Vittamed technologies	Television technique	Vilniaus Vingis
R&D and innovation department	YES	The whole company acts as R&D unit	The whole company acts as R&D unit	YES
Finances for R&D	Internal	International	Internal	Internal and EU

		resources for R&D, EU Structural funds		Structural funds
R&D output	13 patents	10 patents	0 patents	0 patents
R&D cooperation type	Local, academia and companies of the same group	Local academia and international leading companies	Local companies, suppliers	Local, academia
Type of innovation	In house and R&D cooperation with Kaunas university of technology	In house R&D and open innovation in international cooperation	In house R&D, customer and supplier driven	In house R&D and cooperation with R&D institutes of fundamental Physics.
New product development	In house, original R&D based	In house, original R&D based	In house, original R&D based	In house, modified R&D based

**Table 5. Market and competition.**

<b>Market and competition</b>				
<b>Dimension</b>	<b>Axis industries</b>	<b>Vittamed technologies</b>	<b>Television technique</b>	<b>Vilniaus Vingis</b>
Market geography	local	global	international	Local
Market scope	niche	niche	niche	Scale
Competition type	niche	niche	niche	Global
Market type	Organisational and end user, metering	Organisational, medicine and health care	Industrial, TV broadcasting	Industrial,
Type of product by market	Final, systemic	Final, systemic	Final, systemic	Intermediary, component
Uniqueness of product	High, Unique, with similarly performing analogues in the world market	High, Unique, no analogues in the world market	High, Modification, for specific customer , with similarly performing analogues in the world market	Low, component, easily replaceable
Position in value chain	High end	High end	High end	Low end

After summarizing research results, we found common features of successful R&D based firm strategies:

- ?? The firms emerged in the locations with high concentration of diversified competencies, and explored already existing core competencies.
- ?? The firms were able to explore the change via application of existing competencies in a new context of market and competitiveness.
- ?? Despite the temptation to import final solutions, the successful firms in electronic sector has continued investment in R&D and were basing their product solutions on original R&D, and acquisition of desired complementary knowledge from external sources, first of all in the form of new components.
- ?? Continues investments in R&D and innovation and exploitation of less demanding markets not only as income, but also experimental base, has led to the development of original products which are highly competitive in international market today.
- ?? Exploitation of existing local knowledge base in terms of R&D and human resources despite competitive pressure of multinationals.
- ?? Small size and flexibility allowing fast adaptation
- ?? Direct pressure of international competition
- ?? Focus on the final customer with the systemic product in a form of equipment, devices or large systems for use in industry, medicine, or broadcasting via exploration of systemic R&D and engineering competencies.

- ?? Focus on niche markets with highly specialized profiles, both in terms of technology and market specifics
- ?? Shared tradition of R&D and cooperation with other enterprises, R&D establishments and higher education institutions in order to provide better solutions for market
- ?? High R&D orientation at the core of firms strategy as a key success factor

Differently, unsuccessful R&D strategy was featured by:

- ?? Continuity on the same markets and the same technology wave, success of which was basically defined on reaping the final profits of technology LC, while the main competitors were leaving
- ?? Low quality co-operation with R&D sector, partially also because of partners chosen from the fundamental research field, and also because of lack of R&D cooperation competencies
- ?? Scale production orientation with profits operated because of the maintenance of link with the local purchaser
- ?? Low flexibility because of the large size and type of production

Although we can have more in depth look on the factors of success and failure of R&D strategies, implemented by firms, the core factors defining success were:

- ?? Ability to explore change with exploitation of already existing competencies and complex knowledge inherited from the times of being a part of Soviet R&D system, both in science and organization of R&D business.
- ?? Focusing on niche markets where very specific complex knowledge of technology and market is needed
- ?? Development of end product and direct access to its customer
- ?? Continuous upgrade of competencies via R&D and local and international networking
- ?? Exploring all possible types of innovative links – customers, suppliers, R&D and academia, business support institutions, locally and internationally, also applying mobility schemes.

### **Final remarks and further research questions**

As a result of our research, we can state that firms, which emerged from the former R&D system are most likely to drive R&D and knowledge based growth of the small national catch up economies. Being cut from the former R&D system, they were able to create new links, very similar of previous ones, but using market mechanisms and selecting appropriate partners in a new context. In addition, they are aiming to drive national R&D goals, first of all by setting bottom – up relationships with academia - implementing certain research projects, hiring researchers and PhD students, as well as implementing internal programmes for engineer education. In such way, they are creating local poles of competencies around them. In addition, they act as innovation role models for other companies, proving that innovation always pays off. However, no less important conclusion for Lithuanian economy is that firms with relatively long production without R&D tradition will not be able to establish R&D based growth strategies because of lack of the whole set of competencies. On the contrary, we do approach firms with the initial focus on R&D establishing production capacities and

moving to wider range of markets to be served with originally developed products. Further research should focus on how those firms are succeeding in the next development stages, and especially - how they are replacing obsolescing inherited from the Soviet system competencies with the R&D activities in the newly created networks.

Key policy recommendations, arising from our study are focused around the concept of networking and ability to change. Specifically in R&D context it means:

- ?? Development of capacities to cross the disciplines instead of deep specialization in one narrow field
- ?? Development of systemic networks within and across the disciplines
- ?? Development of ability to understand and see R&D driven opportunities
- ?? Strategic focus on R&D based niche producers with national and international linkages

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